EVALUATION OF MECHANICAL PROPERTIES OF ALUMINIUM ALLOY 6061 TITANIUM OXIDE, GRAPHITE AND CHROMIUM HYBRID METAL MATRIX COMPOSITES

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ABSTRACT

Aluminium Metal Matrix Composites (AMMCs) are gaining wide spread acceptance for automobile, aerospace, railway and marine application because of their low density, high strength and good structural rigidity. The objective of this work is to be fabricating hybrid composites with the base metal as Al 6061 aluminum alloy reinforced with different alloying elements of titanium oxide, graphite and chromium. Al 6061 which has better wear resistance and high strength and titanium oxide which has excellent hardness and fracture and toughness are added reinforcement Here the fabrication is done by stir casting. Which involves mixing they require quantities of additives into stirred molten alumina. The prepared specimen is heated at different temperature and Mechanical properties aluminum composite of are evaluated and their suitability is find for various application. The Scanning Electron Micrographs (SEM) of the tested sample indicated uniform distribution of the reinforcement's particles in the matrix without any voids.

Key words: *Hybrid Metal Matrix Composites; Cr, Gr, Tio_2, Stir casting; wear analysis, Reinforcement.*

I. INTRODUCTION

Nowadays, Metal Matrix Composites (MMCs) are under serious consideration to replace conventional materials for a large number of structural applications such as those in the aeronautical/aerospace, transportation, defence and sports industries because of their superior properties. The excellent mechanical properties and the

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comparatively low cost make them as an attractive option [1, 2]. Aluminium is the matrix metal having properties like light weight, high strength and ease of machinability. Alumina which has better wear resistance, high strength, hardness and boron carbide which has excellent hardness and fracture toughness are added as reinforcements. [3]. The MMCs are attractive materials for use in structural applications because they combine favorable mechanical properties, good wear resistance, and low thermal expansion [4]. Hybrid metal matrix composites (HMMCs) are second-generation composites where more than one type, shape, and sizes of reinforcements are used to obtain better properties [5]. Reported that hardness, density of the material increases with increasing the content of ceramic reinforcement and porosity decreases with increasing particles content [6]. Composite materials are one among those new emerging engineering material which plays a major role in auto motive parts [7]. AMCs reinforced with ceramic particles exhibited better mechanical properties than unreinforced aluminum alloys [8, 9]. Particulates-reinforced AMCs were used in electronic packaging industry because their coefficient of thermal expansion can be tailored as per requirement [10]. Particulate AMCs were recently used in the manufacturing of cylinder liners, brake drums, crankshafts and the aerospace and automotive industries because of their high strength, low weight and high temperature stability [11]. Composites are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties that remain separate and distinct within the finished structure. The bulk material forms the continuous phase that is the matrix (e.g., metals, polymers) and the other acts as the discontinuous phase that is the reinforcements (e.g., ceramics, fibers, whiskers, particulates). While the reinforcing material usually carries the major amount of load, the matrix enables the load transfer by holding them together [12].

II. EXPERIMENTAL MATERIALS DETAILS

Aluminium alloy, Al6061, was used as a matrix material and its chemical composition is presented in Table1.Chemical composition of Al6061.

Table 1 Chemical Composition of Al6061 by Weight percentage

Element	**Mg**	**Si**	**Fe**	**Cu**	**Ti**	**Cr**	**Zn**	**Mn**	**Al**
Weight (%)	**0.9**	**0.7**	**0.27**	**0.22**	**0.10**	**0.07**	**0.06**	**0.04**	**Balance**

The composites were fabricated by stir casting method to ensure uniform distribution of the reinforcements. The Al6061 alloy, initially in the form of ingot, which was cut into small pieces then it is placed in the Teflon coated crucible, Aluminum alloy was first melted in an electric furnace Cr, Gr and Tio_2, pre heated to a temperature of about 600°C, were added to the molten metal at 850°C and stirred continuously. The stirring was carried out at 250 rev/min for 10min. Then the preheated reinforcement was poured into a permanent metallic mold. Casting setup is presented in Fig.1.

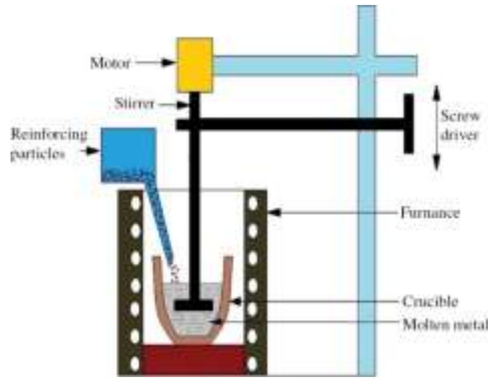

Fig: 1 Stir Casting Method

2.1Experimental procedure

Wear studies of the composites leads to following discussions. Sample size was 240mm length and 20mm dia. fabricated work pieces are shown in Fig 2.

Fig: 2.Fabricated work piece

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The sliding Pin-on-disc type Friction and Wear monitor (DUCOM; TL-20) with data acquisition system, which was used to evaluate the wear behavior of the composite, against hardened ground steel disc (En-32) having hardness 65 HRC and surface roughness (Ra) 0.5 μm. It is versatile equipment designed to study wear under sliding condition only. Sliding generally occurs between a stationary Pin and a rotating disc. The disc rotates with the help of a D.C. motor; having speed range 0-2000 rev/min with wear track diameter 50 mm-180 mm, which could yield sliding speed 0 to 10 m/sec. Load is to be applied on pin (specimen) by dead weight through pulley string arrangement. The system has a maximum loading capacity of 200N. Initially, pin surface was made flat such that it will support load over its entire cross- section called first stage. This was achieved by the surfaces of the pin sample ground using emery paper (80 grit size) prior to test. Run-in-wear was performed in the next stage/ second stage. This stage avoids initial turbulent period associated with friction and wear curves. Final stage/ third stage is the actual testing called constant/ steady state wear. This stage is the dynamic competition between material transfer processes (transfer of material from pin onto disc and formation of wear debris and their subsequent removal). before the test, both the pin and disc were cleaned with ethanol soaked cotton, The vertical height (displacement) of the specimen was continuously measured using linear variable differential transformer (LVDT) of accuracy 1μm during the wear test and the height loss was taken as wear of the specimen.

2.2 Tensile Test

Sample	**Type of Material**	**Load (P) Kgf**	**Diameter Of Specimen (D) mm**	**Length Of Specimen (L) mm**	**Ultimate load In Kgf**	**Breaking load In Kgf**	
Sample I	Al 6061+5%(Cr, gr, Tio2)	4000	20	170	2900	2800	164.11
Sample II	Al 6061+5%(Cr, gr, Tio2)	4000	20	170	2700	2600	152.79
Sample III	Al 6061+5%(Cr, gr, Tio2)	4000	20	170	2600	2500	147.13

Table: 2 Tensile Tests

A tensile test was done using Ultimate universal testing machine (UTM) and the specimen cut as per ASTM: B-557m standard. The results obtained are furnished in table.2

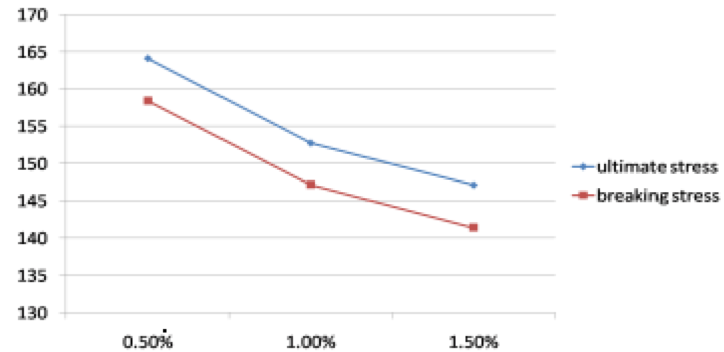

Fig: 3 Tensile Test Vs Wt%

From the experiment is that the tensile strength decrease with the % of hardness reinforcement as shown in fig

2.3 Brinell hardness Test

Brinell hardness was carried out on the three samples and the result furnished on the table. The ball shaped indenter tungsten is used for the test. The diameter of ball indenter is 10mm and the load applied is 500Kgf and the Fig shows the hardness value of three samples if we can note that sample III has the maximum hardness followed by sample I & sample II in all averages.

Sample	Type of material	Load (P) Kgf	Diameter Of Indenter (D) mm	Diameter Of Indentation (d) Mm	Brinell Hardness Number (BHN)
Sample I	Al 6061+0.5%(Cr, gr, Tio2)	500	10	2.6	92.59
Sample II	Al 6061+1.0%(Cr, gr, Tio2)	500	10	2.4	108.92

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Sample III	Al 6061+1.5%(Cr, gr, Tio2)	500	10	2.3	118.76

Table:3 Brinell hardness Test

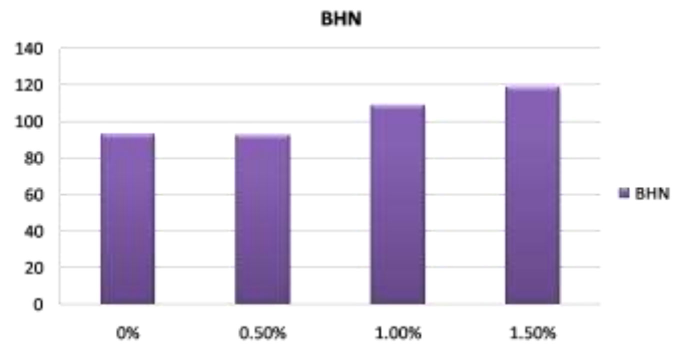

Fig: 4 Brinell hardness Vs Wt%

From the experiment is that the Brinell hardness increase with the % of hardness reinforcement as shown in fig

2.4 Wear Characteristics

The wear rate of as-cast hybrid composites was carried out on pin-on-disc technique to verify the wear resistance characteristics, wear rate of as-cast composites as a function of constant sliding distance 300m, at sliding speed of 2m/s, and applied load of 20 N. The difference in the weights of the specimen between before and after the test, gives the weight loss of the specimen. All these experiments were conducted at room temperature.

2.4.1 Effect of Sliding Distance on Wear Rate

The wear rate increased linearly with the increase in sliding distance. This is due to improper precipitation to form good hardening characteristics in composite and alloy materials. The increase in the hardness and also increase in wear resistance.

Table: 4 Test parameters for wear test

Test Parameters	Units	Values
Volume fraction of composites	%	5,10,15
Load (L)	N	10,20,30
Sliding speed	rpm	286
Track dia (d)	mm	80

2.4.2 Effect of load and sliding distance on wear rate:

The wear rate of the composite specimen increases with increasing sliding distance and load. The fig graphs shows that the reinforced alloy specimen increases more rapidly with applied load compared with the composite specimen. The graph exhibit two regions which is 'running in' and 'steady state' periods. During running-in period the wear rate increased very rapidly with increasing sliding distance. During steady state period, the wear progressed at a slower rate and linearly with increasing sliding distance. The higher wear rate at the initial stage is due to the adhesive nature of the sample to the sliding disc.

The results show that the particulate reinforcement Gr, Cr and Tio_2 has a marked effect on the wear rate .The wear rate of the composite specimen decreases with the increasing weight percentage of particulate reinforcement. The below Table reveals that as the percentage of reinforcement Gr, Cr and Tio_2 increases there is reduction in the percentage of weight loss of the composite material in pin on disc wear tester. The wear resistance increases with the increases in the weight percentage of the reinforcement.

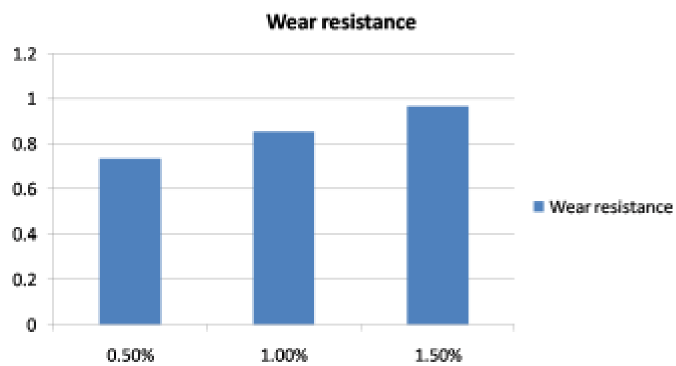

Fig: 5 Specimen vs wear resistance (m/mm^3) with 2 m/s

The following table shows the weight ratio of the sample with different hybrid ratio reinforcement.

Table: 5 The weight ratio of the sample with different hybrid ratio reinforcement

Sample	Specimen Name	Sliding Speed 2m/s		
		Initial weight	Final Weight	Weight loss (gm)
Sample I	Al 6061+0.5%(Cr, gr,Tio2)	3.4237	3.1127	0.311
Sample II	Al 6061+1.0%(Cr, gr,Tio2)	3.1289	2.8813	0.2476

Sample III	Al 6061+1.5%(Cr, gr,Tio2)	2.9938	2.7572	0.2366

2.5 Scanning Electron Microscope (SEM)

It is uses electron in study of light to form of an image the main principle of SEM bombarding of electrons and the secondary electron with reflected are formed as an image. The setup of a Supra 55 SEM the sample holder setup is cleaned with acetone and dried in the sputter coater machine with 240m/s machine with 240 voltages. After the sample is prepared it is micro structure analyzed using SEM.Figure:6 It clearly exhibits the presence of deep permanent grooves and fracture of the oxide layer, which may have caused the increase of wear loss. However, the worn surfaces of the two composites exhibit finer grooves and slight plastic deformation at the edges of the grooves. The surface also appears to be smooth because of the graphite reinforcement content.

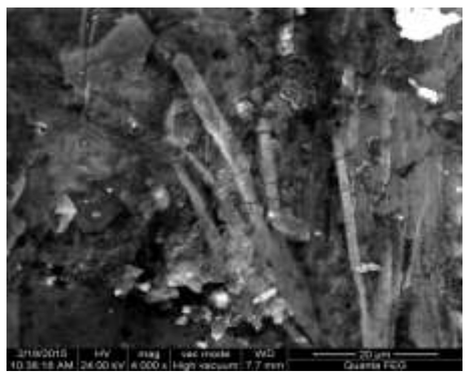

Fig: 6 Magnifications 4000X

III. CONCLUSION

In the present investigation the Al 6061 -Gr - Cr and TiO_2, hybrid composite is successfully fabricated using stir casting process. The mechanical behavior, tribological behavior and machinability behavior are evaluated.

The obtain result can be summarized as follows:

[1]. It has to be inferred that the tensile test sample I (164.11 MPa) is marginal other two samples because of its Al content. But the sample II (152.79 MPa) has higher tensile strength than sample III (147.13 MPa).

[2]. The Brinell hardness sample I (92.59) is marginally lower then of sample III (118.79) but higher that of sample II (108.92).

[3]. Wear rate of composites are reduced with increased weight percentage of the reinforcements.

[4]. The detailed SEM image analysis was done on worm out surface of composite for characteristic in wear mechanism.

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